JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1969, 12, 1017-1022 NUMBER 6 (NOVEMBER)

SOME EFFECTS OF PUNISHMENT ON PAIN-ELICITED AGGRESSION[1]

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Painful mechanical tail-pinch elicited aggressive responses in paired rats; response-contingent electric shock to either forepaws or hindpaws suppressed fighting and stereotyped aggressive postures, including those in which dominance was expressed. There was no evidence that aggression was facilitated by shock that was contingent on pain-elicited aggressive responses. Aggressive responding recovered when shock was discontinued.

EXPERIMENT 1

Paired rats will fight with each other in a stereotyped manner while receiving painful electric shock to feet or tail (Ulrich and Azrin, 1962). The present experiment sought to determine whether this type of aggressive response could be partially or completely suppressed through the use of response-contingent aversive stimulation.

One type of aggressive response (mouse-killing by rats) can be suppressed by aversive stimulation contingent on performance of that response (Myer and Baenninger, 1966), but in the case of aggressive responses elicited by pain, the aversive stimulus is, by itself, the elicitor of the response. Any attempt to suppress the pain-elicited aggressive response by presenting response-contingent punishment is faced with this unique problem. If a given intensity of aversive stimulation elicits fighting between paired rats, then increases in intensity that are contingent on fighting might serve to suppress that response, or they might intensify fighting in proportion to the increase in intensity of the aversive stimulation. The present experiments examined the effects of two different aversive stimuli, one to elicit the aggressive response and one, of a different nature, contingent upon approach to the other rat. A constant, mechanically delivered tail-pinch was used to elicit fighting, and a fairly intense foot shock was chosen as a punishing stimulus.

METHOD

Subjects

In both Experimental and Control groups, there were five pairs of each of the following types of rats: Long-Evans males, Long-Evans females, Sprague-Dawley males, and Sprague-Dawley females. Members of pairs were matched for size and were housed together in single hanging cages (229 by 203 by 203 mm) with free access to food and water. Subjects varied in age from 90 to 150 days.

Apparatus

Fighting bouts and punishment occurred in a grill box, measuring 229 by 203 by 190 mm, with hinged Plexiglas top, two Plexiglas sides, two opaque ends containing 25.4-mm circular holes diagonally opposite each other just above floor level. The floor was composed of 3.2 mm steel rods spaced 13 mm apart. The tail of each member of a pair of rats was extended through the hole in its end of the box and was secured by a soft foam rubber clamp attached to it just outside the box. This left about 127 mm of the subject's tail free for pinching, but minimally restricted its movements in the grill box. Painful pressure was applied to the tail for 10-sec periods by a mechanically actuated spring clamp device. The subject's tail was inserted through a hole at right angles to the center axis of a 25.4-mm diameter Plexiglas

[1]Funds for this research were provided by a grant-in-aid from Temple University. We thank Louise P. Baenninger and Richard L. Solomon for their helpful criticisms of an earlier version of this manuscript, and Neil Beiler for drawing the figures. A report on these experiments was presented at the meeting of the Eastern Psychological Association, Philadelphia, April 10-12, 1969 by JCG. Reprints may be obtained from Ronald Baenninger, Dept. of Psychology, Temple University, Philadelphia, Pa. 19122.

tube, 51 mm long. When a restraining catch was released, a coil spring fixed at one end of the tube exerted a force of 4.4 N along the axis of the tube, thus pinching the portion of subject's tail inserted through the tube. Shock was supplied from a four-line scrambler (Physiological Electronics) that delivered a current intensity of approximately 1.9 ma at the grid.

Procedure

In the Experimental group, once two subjects were properly restrained, current was supplied to the six center bars of the grill box, leaving five bars on either side "safe" for the rat to stand on. So that avoidance of the center bars could be learned, a 60-sec period was given first in which subjects' tails were not pinched. In most cases, the rats rapidly learned to stay on their sides of the electrified grids, but no fighting occurred during this period. After this initial period, a tail pinch was delivered to each subject for 10 sec; this usually caused brief escape attempts followed by aggressive approach to the other subject. After 10 sec, the tail pinchers opened and subjects were given a 50-sec rest period in order to determine whether fighting was stimulus bound. This rest period was also given because of the viciousness of fighting seen in pilot studies; prolonged fighting was found to result in deaths of subjects. The rest period was followed by four more alternating tail-pinch and rest periods for a total experimental period of 6 min containing 50 sec of tail pinching. Three such periods were presented at 24-hr intervals. Fighting was defined as biting contact between subjects: the amount of time during which at least one subject kept its open or partly open mouth in contact with any part of the other subject's body was recorded as the duration of fighting. When both subjects stood on hindfeet with forefeet extended and heads raised, as described by Ulrich and Azrin (1962), this was recorded as stereotyped fighting posture. Duration of these postures was not measured; the occurrence of at least one of these postures by both subjects during a 10-sec tail-pinch bout was simply recorded. If biting contact was made from this posture it was recorded and timed as fighting instead of stereotyped fighting posture. During each 10-sec tail-pinch period, the duration of actual fighting and the occurrence of stereotyped fighting posture were recorded.

Clear expressions of dominance and subordination were also recorded when they occurred during bouts of pain-elicited fighting between pair members. These have been described by Baenninger (1966). One member would lie back while the other would remain above it with forepaws placed on the supine rat. Less extreme forms, in which one rat maintained its head and forepaws raised higher than its opponent's head, were also recorded as dominance and subordination. Independent observations by two observers during 20 tail-pinch bouts showed complete agreement that dominance had been expressed in 19.

After three days of punishment training, Experimental subjects were given three days of recovery trials during which no shock was presented. Control subjects were run in this manner throughout all six days: at no time were they subjected to electric shock. They were not trained to avoid the center bars and were free to aggress during the tail-pinch period without receiving shock.

To demonstrate that the shock used to punish fighting was an adequate stimulus to elicit fighting, five additional pairs of naive male Long-Evans rats, 95 to 130 days of age, were run in the apparatus with electric shock as a painful stimulus. These subjects' tails were restrained but the tail pinchers were not attached. Scrambled shock of 1.9-ma intensity was delivered to pairs of subjects in the testing grill box from the shock source used in the main experiment. Shock duration was 2 sec and onset occurred three times during each of five 10-sec bouts separated by 50 sec. The occurrence of fighting (as defined above) and of stereotyped fighting posture was noted.

Results

Pairs of rats whose approach responses to each other were punished by shock showed a decrease in duration of fighting elicited by tail-pinch (Friedman analysis of variance, $X_R^2 = 10.7$, $df = 2$, $p < 0.01$), while unpunished Controls showed an increase in fighting duration over three days ($X_R^2 = 8.6$, $df = 2$, $p < 0.02$). In recovery from punishment trials, when approach responses of Experimental subjects were no longer punished, there was an increase in fighting by these pairs ($X_R^2 = 8.5$, $df = 2$, $p < 0.02$). On all three days of punishment training, Control pairs fought

more than Experimental pairs (Mann Whitney U test, $U = 28, 9, 13$, $p < 0.001$). Fighting never occurred in the 50-sec rest period between tail-pinch periods, although many pairs in all groups showed the stereotyped fighting posture. These results are shown in Fig. 1.

As can be seen in Table 1, the percentages of 10-sec bouts during which fighting occurred was considerably lower in punished pairs of subjects than in unpunished Controls. When punishment of pain-elicited fighting was discontinued, the percentage of fighting bouts increased immediately almost to the level of Controls. On Day 1 of punishment training, four pairs of Experimental subjects never fought at all during five bouts; two pairs fought in every bout. On Day 3, seven pairs never fought, and no pairs fought in every bout. Control pairs showed quite a different pattern: no pairs failed to fight on every day, 10 pairs fought in every bout on Day 1, and 17 pairs fought in every bout on Day 3. Each group contained 20 pairs of subjects.

Tail-pinches elicited stereotyped upright postures as well as fighting. Members of a pair faced each other with forepaws held horizontally and heads raised; vocalization often accompanied these postures, but rapid movements of the hindpaws, which typically occur in fighting elicited by foot shock, did not occur. Individual members of pairs were never observed to perform stereotyped postures alone, except when one member was momentarily supine before or after a dominance encounter. Subjects that were shocked for approaching each other during 10-sec tail-pinch periods performed fewer stereotyped postures than unshocked Controls only on Day 3 ($U = 20$, $p < 0.002$), due to an increasing frequency of stereotyped postures by Controls over the three days ($X_R^2 = 12$, $df = 2$, $p < 0.01$). As shown in Fig. 2, the Exp. subjects did not show a change over punishment days in stereotypy. Although quantitative data are lacking, they spent part of their time during some bouts in the stereotyped fighting posture, and much of the remainder standing parallel to their end wall with all feet on the ground. Occasional escape attempts were noted, but components of aggressive behavior other than fighting and stereotyped fighting postures were not seen. When shock for approach was discontinued, the frequency of stereotyped postures did increase in Experimental subjects, as shown in Fig. 2. Thus, both pain-elicited fighting and the stereotyped postures associated with fighting were suppressed by shock presented contingent upon approach to the other subject.

Table 1

Percentage of tail-pinch bouts in which fighting occurred.

	Day 1	*Day 2*	*Day 3*
Punishment	44	37	32
Recovery from Punishment	77	77	82
Control (Unpunished)	84	88	94

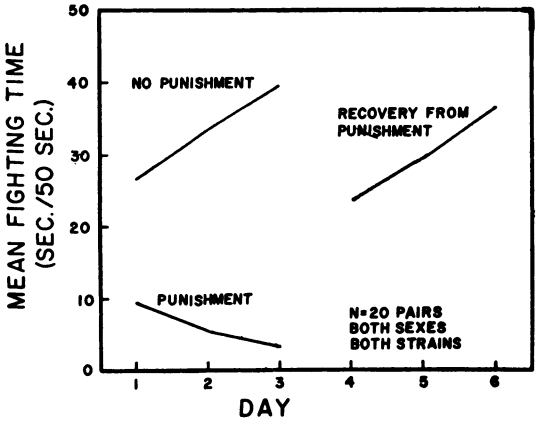

Fig. 1. Mean fighting time (oral contact) of Punished and Nonpunished groups during Days 1 to 3. Recovery from punishment occurred on Days 4 to 6. Fighting was in response to mechanical tail pinch; punishing stimulus was shock to forefeet for approaching opponent.

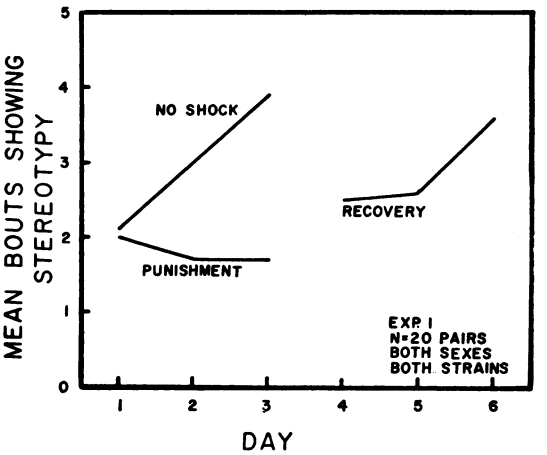

Fig. 2. Mean number of bouts (each lasting 10 sec) in which stereotyped fighting postures were assumed by both members of a pair. There were five bouts each day separated by 50 sec.

In repeated pain-elicited fighting bouts, dominance-subordination postures were frequent. Data on their frequency, but not on their duration, were collected. Control females expressed dominance more frequently than Control males across all three days ($U = 4$, $p < 0.05$). There were no other significant differences on any measure between sexes or strains, and the data for all subjects were pooled for statistical analyses. Punished subjects expressed dominance and subordination postures less frequently than Controls by Day 3 ($U = 20$, $p < 0.002$), presumably because less fighting and stereotyped posturing occurred by Day 3 in these subjects; unshocked Controls continued to express dominance in an approximately constant proportion of those bouts in which the stereotyped fighting posture was adopted (Table 2).

Pairs of subjects that received 2-sec shocks but not tail-pinch fought vigorously during the majority of 15 foot shocks. Two pairs fought every time they were shocked; the other three pairs always fought during the last six shocks, but occasionally failed to fight during the first nine. Stereotyped fighting posture was seen in every pair during at least three of the intershock intervals.

Table 2

Percentage of encounters in which dominance was expressed.

	Day 1	*Day 2*	*Day 3*
Punishment	56	28	18
Recovery from Punishment	46	42	40
Control (Unpunished)	59	57	59

EXPERIMENT 2

Fowler and Miller (1963) found that the locus of punishment may determine whether response-contingent aversive stimulation facilitates or suppresses behavior. Because suppression of pain-elicited aggressive behavior occurred when subjects were shocked on their forepaws in Exp. 1, we wondered whether suppression of such behavior would result when shocks to subjects' hindpaws were made contingent upon fighting. Since such shocks to paired rats may elicit unconditioned approach responses to each other, while they are receiving painful tail-pinch stimulation, it seemed possible that facilitation of fighting would result under these conditions.

Method

Ten pairs of experimentally naive, male Sprague-Dawley rats were assigned to either an unshocked Control group (five pairs) or an Experimental group that received shock primarily on their hindpaws when attacks were made (five pairs). The procedure was identical to Exp. 1, except that the four grill bars at each end of the grill box were wired for shock delivery. When subjects in the Experimental group attacked each other during any of the five 10-sec periods of tail pinching, the shock was turned on until the attack ceased. Time spent fighting was recorded as was frequency of stereoypted postures and expressions of dominance. Control subjects were given six daily trials without shock, while Experimental subjects received three days of punishment training, followed by three days in which pain-elicited aggression was not punished.

Results

Pain-elicited attacks were suppressed when followed by hindfoot shock on Days 1 to 3, and attacks recovered when shock was discontinued on Days 4 to 6. These results are shown in Fig. 3. The duration of fighting by subjects shocked on their hindfeet for attacks was lower on each day than in those subjects that never received shock (Mann Whitney U tests, $p < 0.05$). For purposes of comparison, the data of Experimental Sprague-Dawley male subjects from Exp. 1 are included in Fig. 3; this group received response-contingent forefoot shock and showed a significantly shorter duration of fighting than the group shocked on hindfeet on Days 1 to 3, but not on Days 4 to 6 when shock was no longer presented to either group. Thus, neither of the punished groups recovered to the level of fighting shown by unpunished Controls.

As in Exp. 1, unpunished Controls showed an increase over six days in the frequency of stereotyped fighting postures, of which about 50% contained bouts in which dominance was expressed. Also replicating the results of Exp. 1, punished subjects (response-contingent shock to hindfeet) showed an increase in stereotyped fighting posture only when shocks were discontinued, so that by the third day of re-

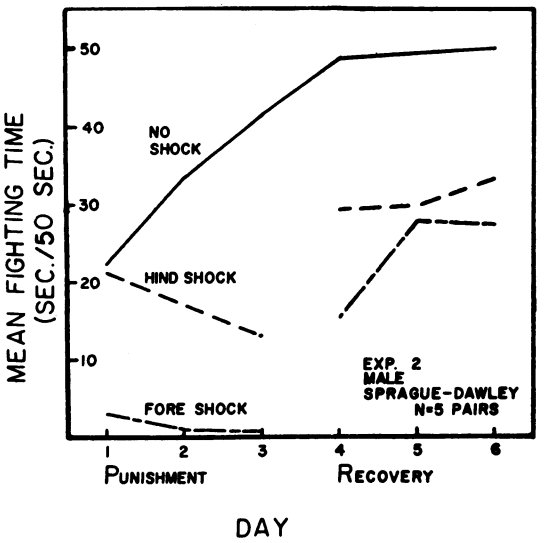

Fig. 3. Fighting time when attacks were followed by No Shock, Hindfoot Shock, or Forefoot Shock. No shocks were given during Recovery from punishment.

covery trials they were not performing significantly fewer stereotyped fighting postures than unpunished Controls. ($\overline{X}_{Experimental} = 3.6$ stereotyped posture bouts out of 5; $\overline{X}_{Control} = 3.9$). During punished trials, there was a decrease in the percentage of stereotyped fighting bouts in which dominance was expressed, as in Experimental subjects of Exp. 1 (see Table 2). Thus, all three aggressive acts were suppressed, even though punishment was explicitly contingent only upon biting attacks.

In both Exp. 1 and 2, several pairs of subjects in both shocked and unshocked groups maintained the stereotyped fighting postures for up to 1 hr after being returned to their home cages, although systematic data were not collected on this behavior. Attacks occurred, although infrequently. Such transfer is of some interest because no painful stimulation was administered to subjects in their home cages at any time. The only stimulus element common to grill box and home cage was the other subject.

DISCUSSION

Not reported previously in studies of pain-elicited fighting is the finding that dominance-subordination contacts occur repeatedly between the opponents during painful stimulation. These contacts often appeared similar to those observed by Grant and Chance (1958) and by Baenninger (1966) in non-stimulated rats. The fact that such encounters do occur in rats receiving painful tail pinches lends credence to the assumption that the biting, sparring, and stereotyped postures found by Azrin and his co-workers are similar to aggressive behavior shown by rats in more natural settings, and not artifacts of painful stimulation.

Only fighting (defined by biting attacks) was explicitly punished in these experiments; despite this, the frequency of stereotyped fighting postures and the expression of dominance were suppressed as was actual fighting. This finding suggests an essential unity of the three aggressive behaviors measured in this experiment.

One theory proposed to explain the suppressing effects of punishment on behavior is the Competing Skeletal Response hypothesis proposed by Guthrie (1934), in which initially unconditioned responses to shock become conditioned to enviromental cues of the shock situation or to response-produced cues. Such conditioned responses may interfere with previously punished responses. In the presence of another rat, one unconditioned response to shock is aggression, which is clearly not incompatible with approaching or attacking the other rat. According to Guthrie's hypothesis, punishment by shock of pain-elicited approach or attack responses toward another rat will facilitate aggression because aggression and the response to shock are compatible.

If aggression is assumed to be the principal unconditioned response to shock, the results of Exp. 1 do not confirm Guthrie's prediction. However, if withdrawal from electrified grill bars is the principal unconditioned response to forefoot shock then suppression of pain-elicited attacks might be expected due to interference of the withdrawal response to forefoot shock with attacks. Azrin, Hutchinson, and Hake (1967) found that rats will escape shock rather than attack if both alternatives are available, and that monkeys will avoid shock if allowed to do so, and thus fail to attack. In Exp. 1, rats avoided electrified grill bars and failed to attack or show stereotyped fighting postures even though they were still receiving stimulation sufficient to induce controls to fight with vigor.

When shock was delivered primarily to subjects' hindfeet after pain-elicited attacks, escape responses were possible only by approach-

ing the other subject in the center of the grill box. This had the effect of bringing subjects closer together while they were being painfully stimulated by the tail pinches and, according to Guthrie's hypothesis, should have increased the probability of aggressive encounters. However, compared to unpunished Controls, these subjects spent less time fighting.

On the basis of the present data, we conclude that response-contingent shock interferes with pain-elicited attacks, stereotyped fighting postures, and the expression of dominance regardless of whether shock is delivered to fore or hindfeet of the rat. Less interference results if shock is delivered primarily to hindfeet. This latter finding, although in the direction predicted by Guthrie's hypothesis, does not confirm that hypothesis, because the overriding effect of response-contingent shock, wherever delivered, was to suppress pain-elicited aggressive behavior. This was the case even though the shock alone, in the absence of other painful stimulation, was sufficient to elicit aggression between paired rats.

REFERENCES

Azrin, N. H., Hutchinson, R. R., and Hake, D. F. Attack, avoidance, and escape reactions to aversive shock. *Journal of Experimental Analysis of Behavior*, 1967, **10**, 131-148.

Baenninger, L. P. The reliability of dominance orders in rats. *Animal Behaviour*, 1966, **14**, 367-371.

Fowler, H. and Miller, N. E. Facilitation and inhibition of runway performance by hind- and forepaw shock of various intensities. *Journal of Comparative and Physiological Psychology*, 1963, **56**, 801-805.

Grant, E. C. and Chance, M. R. A. Rank order in caged rats. *Animal Behaviour*, 1958, **6**, 183-194.

Guthrie, E. R. Reward and punishment. *Psychological Review*, 1934, **41**, 450-460.

Myer, J. S. and Baenninger, R. Some effects of punishment and stress on mouse killing by rats. *Journal of Comparative and Physiological Psychology*, 1966, **62**, 292-297.

Ulrich, R. E. and Azrin, N. H. Reflexive fighting in response to aversive stimulation. *Journal of Experimental Analysis of Behavior*, 1962, **5**, 511-520.

Received 28 April 1969.